PRELIMINARY RESEARCH PROPOSAL (COE) (FY07)

TITLE:	Fish Passage and Survival at Lower Monumental and Ice Harbor Dams
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STUDY CODES:	SPE-W-05-1, SPE-W-07
PROJECT DURATION:	FY2007
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PROJECT SUMMARY

Research Goals

The goal of this study is to evaluate fish passage behavior including forebay residence time, passage distribution, passage efficiency, passage effectiveness, fish passage efficiency (FPE), fish guidance efficiency (FGE), and tailrace egress, and to provide estimates of project survival and route-specific survival for radio-tagged juvenile salmonids (*Oncorhynchus* spp.) passing Lower Monumental and Ice Harbor Dams. Evaluations will focus on passage and survival in conjunction with a removable spillway weir (RSW).

Definitions of Passage Behavior Metrics and Survival Estimates

Fish passage behavior performance metrics, project survival, and route-specific survival as used in this proposal are defined as follows:

Immediate Forebay:	Portion of the forebay from the upstream limit of the boat restricted zone (BRZ) to the concrete.
Immediate Tailrace:	Portion of the tailrace from the concrete downstream to the downstream limit of the BRZ.
Passage Efficiency:	The number of fish passing the dam through a given passage route (spillway, RSW, bypass system) divided by the total number of fish passing the dam.
Passage Effectiveness:	The proportion of fish passing the dam through a given passage route (spillway, RSW) divided by the proportion of water passing through that route.
Fish Passage Efficiency (FPE):	The number of fish passing the dam through non-turbine routes divided by total project passage.
Fish Guidance Efficiency (FGE):	The number of fish passing the dam through the juvenile bypass system divided by the total number of fish passing the dam through the powerhouse.
Tailrace Egress:	The elapsed time from project passage to exit from the immediate tailrace.
Forebay Residence Time:	The elapsed time from arrival in the immediate forebay of the dam until passage through the spillway, bypass, or turbines.
Pool Survival:	Survival between the immediate tailrace of one dam to the immediate forebay of the next dam downstream.
Relative Dam Survival:	Survival from the upstream limit of the immediate forebay and the release location

	of reference groups downstream of the dam.
Relative Route-specific Survival:	Survival between detection within a passage route and the release location of reference groups downstream of the dam.

Study Objectives

Specific study objectives may change based on final analysis of 2006 research or changes in project operations.

Objective 1

Assess passage behavior and estimate survival for yearling Chinook salmon relative to operation of a removable spillway weir at Lower Monumental Dam.

We propose to release radio-tagged yearling Chinook salmon (*O. tshawytscha*) upstream and downstream from Lower Monumental Dam to evaluate passage behavior (forebay residence time, passage distribution, spill efficiency, spill effectiveness, FPE, FGE, tailrace egress) and to estimate dam survival as it relates to operation of the RSW. In addition, we will estimate RSW and spillway passage survival under two operational conditions using a paired-release design.

Objective 2

Assess passage behavior and estimate survival for juvenile steelhead relative to operation of a removable spillway weir at Lower Monumental Dam.

We propose to release radio-tagged juvenile steelhead (*O. mykiss*) upstream and downstream from Lower Monumental Dam to evaluate passage behavior (forebay residence time, passage distribution, spill efficiency, spill effectiveness, FPE, FGE, tailrace egress) and to estimate dam survival as it relates to operation of the RSW. In addition, we will estimate RSW and spillway passage survival under two operational conditions using a paired-release design.

Objective 3

Assess passage behavior and estimate survival for subyearling Chinook salmon relative to operation of a removable spillway weir at Lower Monumental Dam.

We propose to release radio-tagged subyearling Chinook salmon (*O. tshawytscha*) upstream and downstream from Lower Monumental Dam to evaluate passage behavior (forebay residence time, passage distribution, spill efficiency, spill effectiveness, FPE, FGE, tailrace egress) and to estimate dam survival as it relates to operation of the RSW.

In addition, we will estimate RSW and spillway passage survival under two operational conditions using a paired-release design.

Objective 4

Assess passage behavior and estimate survival for yearling Chinook salmon relative to operation of a removable spillway weir at Ice Harbor Dam.

We propose to monitor radio-tagged, yearling Chinook salmon released as part of Objective 1 prior to and following passage through Ice Harbor Dam to evaluate passage behavior (forebay residence time, passage distribution, passage efficiency, passage effectiveness, FPE, FGE, and tailrace egress) as it relates to operation of the RSW. In addition, we will estimate pool, dam, RSW, and spillway passage survival under two operational conditions for fish released in Objective 1 using a paired-release design.

Objective 5

Assess passage behavior and estimate survival for juvenile steelhead relative to operation of a removable spillway weir at Ice Harbor Dam.

We propose to monitor radio-tagged, juvenile steelhead (*O. mykiss*) released as part of Objective 2 prior to and following passage through Ice Harbor Dam to evaluate passage behavior (forebay residence time, passage distribution, passage efficiency, passage effectiveness, FPE, FGE, and tailrace egress) as it relates to operation of the RSW. In addition, we will estimate pool, dam, RSW, and spillway passage survival under two operational conditions for fish released in Objective 2 using a paired-release design.

Objective 6

Assess passage behavior and estimate survival for hatchery subyearling Chinook salmon relative to operation of a removable spillway weir at Ice Harbor Dam.

We propose to release radio-tagged subyearling Chinook salmon (*O. tshawytscha*) above and below Ice Harbor Dams. We will monitor these fish prior to and following passage through Ice Harbor Dam to evaluate passage behavior (forebay residence time, passage distribution, passage efficiency, passage effectiveness, FPE, FGE, and tailrace egress) as it relates to operation of the RSW. In addition, we will estimate dam, RSW, and spillway passage survival under two operations using a paired-release design.

Relevance to the Biological Opinion

This study addresses Reasonable and Prudent Alternatives in sections 9.6.1.4.5 and 9.6.1.4.6 in the 2000 FCRPS Biological Opinion (NMFS 2000). This study also addresses Question 3 and 7 of the Ten Key Questions for Salmon Recovery in the NMFS-NWFSC Salmon Research Plan (NWFSC 2002).

PROJECT DESCRIPTION

Relevance

The Columbia and Snake River Basins have historically produced some of the largest runs of Pacific salmon Oncorhynchus spp. and steelhead O. mykiss in the world (Netboy 1980). More recently, however, some stocks have decreased to levels that warrant listing under the U.S. Endangered Species Act of 1973 (NMFS 1991, 1992, 1998, 1999). Anthropogenic factors that have contributed to the decline and loss of some salmonid stocks include overfishing, hatchery practices, logging, mining, agricultural practices, and dam construction and operation (Nehlsen et al. 1991). A primary focus of recovery efforts for depressed stocks has been assessing and improving fish passage conditions at dams.

The spillway has long been considered the safest passage route for migrating juvenile salmonids at Columbia and Snake River dams. Holmes (1952) reported survival estimates of 96 (weighted average) to 97% (pooled) for fish passing Bonneville Dam spillway during the 1940s. A review of 13 estimates of spillway mortality published through 1995 concluded that the most likely mortality rate for fish passing standard spillbays ranges from 0 to 2% (Whitney et al. 1997). Similarly, recent survival studies on juvenile salmonid passage through various routes at dams on the lower Snake River have indicated that survival was highest through spillways, followed by bypass systems, then turbines (Iwamoto et al. 1994; Muir et al. 1995a, b, 1996, 1998, 2001; Smith et al. 1998). Pursuant to the National Marine Fisheries Service (NMFS) 2000 Biological Opinion (NMFS 2000), project operations at Lower Monumental Dam have relied on a combination of voluntary spill and collection of fish for transportation to improve hydrosystem-passage survival for migrating juvenile salmonids. Efforts to improve juvenile salmonid passage and survival at Ice Harbor Dam have focused on increasing the proportion passing via voluntary spill.

Surface collection and bypass systems have been identified as a viable alternative for increasing survival and FPE for migrating juvenile salmonids at hydroelectric dams on the Snake and Columbia Rivers. At the Wells Dam project on the Columbia River where the spillway, located over the turbine units, 90% of the juvenile fish pass through the spillway while spilling just 7% of the total discharge. Studies evaluating a removable spillway weir (RSW) installed at Lower Granite Dam in 2001 have indicated that the RSW is an effective and safe means of passing migrating juvenile salmonids (Anglea et al. 2003; Plumb et al. 2003, 2004). In 2002, the Lower Granite Dam RSW passed 56–62% of radio-tagged fish while discharging only 8.5% of the total discharge. In 2003, passage effectiveness ratios were 8.3-9.9:1 through the RSW. Additionally, survival for radio-tagged fish passing through the RSW was estimated at 98% (95% CI, ±2.3%).

Juvenile anadromous salmonids in Columbia River Basin generally migrate in the upper 3 to 6 m of the water column. However, juvenile fish passage routes at dams on the lower Columbia and Snake Rivers require fish to dive to depths of 15 to 18 m in order to enter a passage route. Engineers and biologists within the USACE have developed the RSW to provide a surface-oriented spillway passage. The RSW uses a traditional spillway and is attached to the upstream face of a spillbay. In the lower Snake River, RSWs have been installed at Lower Granite Dam in 2001 and Ice Harbor Dam in 2005. An RSW is scheduled for installation at Lower Monumental Dam prior to the 2007 spring outmigration.

The proposed study is to examine fish passage behavior including forebay delay, passage distribution, passage efficiency, spill effectiveness, FPE, FGE, and tailrace egress as well as project and route-specific survival estimates for juvenile salmonids passing Lower Monumental and Ice Harbor Dams during voluntary spill with an RSW operating at each project. Results of this study will be used to inform management decisions for operation of an RSW at Lower Monumental and Ice Harbor Dams and to optimize survival and passage for juvenile salmonids. This study addressed research needs outlined in SPE-W-05-1 and SPE-W-07 of the USACE, Northwestern Division, Anadromous Fish Evaluation Program.

Methods

Numerous research methods have been and are currently being used to evaluate fish passage and/or estimate survival, including PIT tags, balloon tags, hydroacoustics, and radiotelemetry. Each research method has its advantages and disadvantages, but options are limited in some situations because of lack of sampling capabilities downstream or where fish behavior and survival estimates are needed. In these situations, radiotelemetry is an ideal method for evaluating passage behavior and estimating survival. During 1999 studies at Lower Granite Dam, NMFS and United States Geological Survey (USGS) compared the performance of sham radio-tagged yearling Chinook salmon (both gastrically and surgically implanted tags) to PIT-tagged fish (Hockersmith et al. 2003). Results, based on PIT-tag detections, indicated that radio tags did not significantly affect detection probability (approximately equal to FGE in the absence of spill) or survival of yearling Chinook salmon between the tailraces of Lower Granite and Lower Monumental Dams (a 106-km reach which included two dams and two reservoirs).

Study Area

The study area includes a 125-km river reach from about 6 km above Lower Monumental Dam on the lower Snake River to McNary Dam on the lower Columbia River (Figure 1). Lower Monumental Dam, the second dam upstream of the mouth of the Snake River, is located 67 km above the confluence of the Snake and Columbia Rivers in Washington State. Ice Harbor Dam, the first dam upstream of the mouth of the Snake River, is located 16 km above the confluence of the Snake and Columbia Rivers in Washington State.

Fish Collection, Tagging, and Release

Radio tags will have a user-defined shut-off after 10 d, and be pulse-coded for identification of individual fish. Each radio tag will weigh 0.9 g in air or less and have a 30 cm long external antenna.

River-run yearling Chinook salmon, juvenile steelhead, and subyearling Chinook salmon will be collected from the daily smolt monitoring sample at either Lower Monumental or Little Goose Dams from approximately 1 May through 15 July. We will use only fish that have not been previously PIT tagged, that have no visual signs of disease or injury, and that weigh 12 g or more. Fish will be anesthetized with tricaine methanesulfonate (MS-222) and sorted in a recirculating anesthetic system. Fish for treatment and reference release groups will be randomly selected from the daily smolt-monitoring sample and transferred through a water-filled, 10.2-cm hose to a 935-L holding tank. Following collection and sorting, fish will be maintained via flow-through river water and held a minimum of 18 h prior to radio tagging.

Fish will be surgically tagged with a radio transmitter using techniques described by Adams et al. (1998). A PIT tag was also inserted with the radio transmitter so that test fish will be separated by code in the fish collection system and returned to the river (Marsh et al. 1999). Fish handling methods such as water-to-water transfers and pre-anesthesia will minimize injury and stress to fish during the sorting and tagging process. Trained NMFS personnel will supervise all tagging operations

Immediately following tagging, fish will be placed into a 19-L, aerated recovery containers (two fish per container) and held a minimum of 18-h for recovery and determination of post-tagging mortality. Fish released near Lower Monumental Dam will be held in tanks below the raceways at Lower Monumental Dam. Fish released near Ice Harbor Dam will be held in tanks on the navigation lock wing wall at Ice Harbor Dam. Fish holding containers are perforated with 1.3-cm holes in the top half of the container to allow exchange of water during holding. Recovery containers are closed and transferred to a 1,152-L holding tank designed to accommodate up to 28 containers. All holding tanks will be supplied with flow-through water during tagging and holding and aerated with oxygen during transport to release locations.

We will use a paired-release study design with treatment fish released upstream of the dam and reference fish released into the tailrace. After the post-tagging recovery period, fish will be moved in their recovery containers from the holding area to release locations. For objectives 1, 2, and 3 the treatment fish will be released 7 km upstream from Lower Monumental Dam and the reference groups will be released approximately mid-channel into the tailrace. To provide mixing of treatment and reference groups, treatment groups will be released all at one time twice daily (daytime and nighttime periods), and reference release groups will be released over a 4-h period twice daily (daytime and nighttime periods).

For objectives 4 and 5 the treatment groups at Ice Harbor Dam will be created from fish released for objectives 1 and 2 and subsequently detected on the entrance line at the upstream end of the boat restricted zone (BRZ) in the forebay of Ice Harbor Dam. For objective 6 the treatment fish will be released 7 km upstream from Ice Harbor Dam. The references groups at Ice Harbor Dam will be released over a 4-h period twice daily (daytime and nighttime periods) approximately mid-channel into the tailrace. The specific reference-group release locations will be determined from operations testing on 1:55 scale model of Lower Monumental and Ice Harbor Dams at the USACE Engineer Research and Development Center in Vicksburg, MS.

Lower Monumental and Ice Harbor Dams project operations during 2007 have not been finalized at this time. Expectations are that Lower Monumental and Ice Harbor Dams will each operate under two conditions in 2006. It is anticipated that these operations will follow a 4-day randomized block. Each block will comprise of 2-days of operation A and 2-days of operation B. The specifics of operation A and B at each project will be developed by the USACE and regional fish management agencies prior to the 2007 outmigration. Project operation data at Lower Monumental and Ice Harbor Dams will be collected every 5 min by the USACE. Project operations assigned to treatment fish correspond to conditions closest to time of passage. For treatment fish that pass the dam without a specific passage time, project operations are assigned based on conditions closest to the time of first detection recorded in the tailrace. For treatment fish that do not pass the dam, project operations corresponded to conditions closest to the time of forebay entry. Operational conditions assigned to reference fish correspond to conditions closest to time of release. Treatment fish assigned to a specific project operation will be paired with reference fish released during the same project operation.

Data Collection, Processing, and Analysis

The locations of proposed fixed telemetry receiver sites at Lower Monumental Dam are summarized in Table 1 and Figure 2. The locations of proposed fixed telemetry receiver sites at Ice Harbor Dam are summarized in Table 2 and Figure 3. Locations of telemetry transects fore estimating survival are presented in Figure 1. Telemetry data will be retrieved through an automated process that downloads networked telemetry receivers up to four times daily. After downloading, individual data files will be compressed by recording the first time a radio-tagged fish was detected and counting the number of detections where the time difference between adjacent detections is less than or equal to 1 min. When the difference between adjacent detections becomes greater than 5 min, a new line of data is created. All compressed data will be combined and loaded into a database, where automated queries and algorithms will be used to remove erroneous data. On the cleaned data set, detailed detection histories will be created for each radio-tagged fish. These detection histories will be used to calculate arrival time in the forebay, determine forebay approach patterns, passage route and timing, tailrace exit timing, and timing of downstream detections for individual radio-tagged fish.

Forebay Residence Time

A schematic of the model used for forebay delay is presented in Figures 4 and 5. Forebay arrival time will be based on the first time a fish is detected on the forebay entry line at the upstream end of the BRZ. Forebay residence time will be determined for fish that had been released upstream from the dam, detected entering the forebay, detected in a passage route, and detected in the immediate tailrace on either the stilling-basin or tailrace-exit telemetry receivers (Figure 2 and 3). Forebay residence time for individual fish will be measured as the time between the first detection on the forebay entrance line at the upstream end of the BRZ to the last detection in a passage route. Forebay residence data will be partitioned by project operations based on operations at the time individual fish pass the dam. Forebay residence times for fish passing during different conditions will be compared using one-way analysis of variance (ANOVA) where project operations is the treatment factor and passage day is a random (blocking) factor.

Approach and Passage Distribution

A schematic of the model used for passage distribution is presented in Figures 4 and 5. Approach patterns will be based on the first detection at either underwater dipole spillway antennas (Beeman et al. 2004) or on stripped coax underwater antennas (Knight et al. 1977) on the standard-length traveling screens (Figures 2 and 3). Approach distributions will be partitioned by project operations based on operations at the time individual fish pass the dam.

The route of passage through the dam will be based on the location of the last time a fish was detected on a passage-route antenna (Figures 2 and 3). Passage will be confirmed by subsequent detection in the tailrace by stilling-basin, draft tube exit, or tailrace-exit telemetry antennas. Tailrace detections are needed to validate passage because it is possible for fish to be detected on a passage-route antenna while still in the forebay. Spillway passage will be assigned to fish that were detected in the tailrace of the dam after last being detected in the forebay on antenna arrays deployed along the pier nose on the sides of individual spillbays. Powerhouse passage will be assigned to fish last detected in a turbine intake prior to detection in the tailrace of the dam.

Powerhouse passed fish will be further partitioned into either turbine or the juvenile bypass system (JBS) passage based on the presence or absence of JBS detections (PIT-tag or telemetry detection). Fish that are assigned to powerhouse passage without detections in the JBS will be assigned to turbine passage. Passage distribution will include fish released above a dam, detected in a passage route, and detected in the immediate tailrace on either the stilling-basin, draft tube exit antennas or tailrace-exit telemetry receiver. Approach and passage distributions will be partitioned by project operations and compared.

Fish Passage Performance Metrics

We will evaluate the following fish passage performance metrics: spill efficiency, spill effectiveness, fish passage efficiency (FPE), and fish guidance efficiency (FGE). Spill efficiency is the number of fish passing the dam via the spillway divided by the total number of fish passing the dam. Spill effectiveness is the proportion of fish passing the dam via the spillway divided by the proportion of water spilled. FPE is the number of fish passing the dam through non-turbine routes divided by total number of fish passing the dam. FGE is the number of fish passing the dam through the JBS divided by the total number of fish passing the dam through the powerhouse (turbines and JBS). Fish passage metrics will be partitioned by project operations and compared.

Tailrace Egress

A schematic of the model used for tailrace egress is presented in Figures 4 and 5. Tailrace egress will include fish detected in a passage route and detected on the tailrace exit array. Tailrace egress will be the elapsed time between last detection on a passage route and last detection on the tailrace exit array. Tailrace egress data will be partitioned by project operations based on operations at the time individual fish pass the dam. Tailrace egress times for fish passing during different conditions will be compared using one-way analysis of variance (ANOVA) where project operations is the treatment factor and passage day is a random (blocking) factor.

Survival Estimates

A schematic of the model used for dam and route specific survival is presented in Figures 6 and 7. Radiotelemetry detection data for all release groups will be compiled and processed as described in Eppard et al. (2000). The "complete capture history" protocol (Burnham et al. 1987) will be used to estimate project survival and detection probabilities by applying the single release-recapture model (Cormack 1964; Jolly 1965; Seber 1965; Skalski et al. 1998; Skalski et al. 2001) independently to the treatment and reference groups. The release-recapture data will be analyzed using the Survival with Proportional Hazards (SURPH) statistical software developed at the University of Washington (Smith et al. 1994). Route-specific survival will be estimated for all passage routes where adequate numbers of fish pass the project to provide estimates with a precision level of at least +/- 0.07. Survival estimates and passage behavior metrics for the two spill patterns will be compared by analysis of variance (ANOVA). Correlations between survival, passage behavior, project operations and environmental conditions will be examined by regression analysis to determine how these factors affect project survival, route-specific survival, and fish passage. Survival estimates will be based on detections of individual fish at telemetry transects on the Snake River near burr canyon, at Ice

Harbor Dam on the Snake River, the Snake River mouth and on the Columbia River near Burbank, WA, and the forebay of McNary Dam (Figure 1). Capture histories of treatment and reference groups will be partitioned into three periods for survival estimation. For evaluations at Lower Monumental Dam these three periods will be detection at Burr Canyon, Ice Harbor Dam and detection downstream from Ice Harbor Dam. For evaluations at Ice Harbor Dam these three periods will be detection at the Snake River mouth, the Columbia River near Burbank, WA, and the forebay of McNary Dam. Minimum detection probabilities for each transect are expected to be 75%. At Lower Monumental and Ice Harbor Dams, telemetry receivers will utilize underwater and air antennas to monitor the forebay, all routes of passage, and the tailrace to detect radio-tagged fish approaching, passing, and exiting the tailrace of the dam (Figures 2 and 3).

Treatment groups for estimates of survival will be comprised of fish passing during a specific operation. The reference groups of fish for estimates of survival will be grouped by the operations during release. Relative survival estimates will be the ratios of survival estimates of treatment groups over the reference groups. Differences among project operation treatments in forebay residence times, tailrace egress, and survival will be evaluated using ANOVA, likelihood ratio tests, and/or nonparametric methods as appropriate. Chi-square, goodness-of-fit tests will be used to test equal probability of detection (mixing) over time between treatment and control groups. Adult return rates of fish from this study are expected to be too small for formal analysis.

Survival estimates and passage behavior metrics will be analyzed using appropriate statistical tests. To provide continuity between analysis and interpretation of survival and passage behavior, we will use the same pool of fish for both passage behavior and survival. Assumptions, proposed sample sizes, and estimated precision for the proposed evaluations are presented in Tables 3, 4, and 5. The number of release groups and number of fish per release group were calculated to maximize the ability to provide a project survival estimate with 95% confidence intervals of +/- 4%. Sample sizes for releases were calculated based on data from radio-tagged salmonids released at Lower Monumental and Ice Harbor Dams in 2002 through 2006 and annual PIT-tag survival estimates in the Lower Snake and Columbia Rivers (Table 1). We used conservative assumptions in calculating sample sizes; our actual precision will likely be greater than shown. To test the assumption that a dead fish carrying an active radio tag could not float past a downstream detection line yielding a false-positive detection and biasing the survival estimate, any tagging mortalities will be released in conjunction with release groups into the tailrace of Lower Monumental and Ice Harbor Dams. At present, no formal analysis of adult returns of PIT-tagged fish used in this study is anticipated.

Avian Predation

Predation from the Caspian Tern *Sterna caspia* colony on Crescent Island, located 12.9 km downstream from the Snake River mouth (Figure 1), will be evaluated by physical recovery of radio transmitters that are visible on the island and by PIT tag detection. Radio tags and PIT tags will be recovered on the tern colony at Crescent Island during fall 2007 after the birds have left the island. Radio-tag serial numbers will be used to identify individual tagged fish. PIT-tag detections and recovery of radio transmitters at Crescent Island may also be provided by NMFS (B. Ryan, NOAA Fisheries, personal communication) and Real Time Research, Inc. (A. Evans, Real Time Research, Inc., personal communication). There is an ongoing monitoring effort to recover PIT tags from active Caspian Tern colonies in the region conducted by NOAA Fisheries and by the Columbia Bird Research group.

Critical Limitations

The degree of success of this study will be contingent upon six primary factors: 1) adequate numbers of fish being collected and radio tagged during the required time frame; 2) the pre-determined replicates and sample sizes providing the necessary precision for the survival estimates; 3) adequate numbers of radio-tagged fish passing through each passage route to estimate route-specific survival with precision and to evaluate passage behavior; 4) radiotelemetry receivers, PIT-tag detectors and bypass systems at downstream dams operating for the duration of the study; 5) the acquisition and availability of detailed operations data in order to correlate passage behavior and survival with project operations; and 6) access to Lower Monumental and Ice Harbor Dams outside normal business hours.

PROJECT IMPACTS

1. Collection, tagging, and fish-holding operations at Little Goose, Lower Monumental and Ice Harbor Dams will be coordinated with the Project Office and Smolt Monitoring Program personnel.
2. All fish for the study will either be collected at Little Goose or Lower Monumental Dams. Changes in the daily smolt monitoring sampling schedule and sample rates may be required to meet daily target numbers for tagging.
3. Activities related to marking and/or releasing fish at Lower Monumental and Ice Harbor Dams may occur during all hours; therefore, unusual vehicle traffic and activity may occur outside normal COE duty hours during April through July.
4. Installation, deployment, maintenance, downloading, and removal of telemetry equipment by NMFS personnel including receivers, antennas, and cables will occur at Lower Monumental and Ice Harbor Dams from February through July. Temporary spill outages may be required to test and service telemetry antennas.
5. Moorage space for release barges will be needed at Lower Monumental and Ice Harbor Dams.
6. At least two downstream and two upstream lockages will be needed on a daily bases at both Lower Monumental and Ice Harbor Dams in order to release fish above and below the projects.
7. A reliable, uninterruptible power supply will be required at both projects for operation of radiotelemetry receivers.

BIOLOGICAL EFFECTS

These studies will be carried out using an ESA Section 10 Permit issued to the National Marine Fisheries Service.

TECHNOLOGY TRANSFER

Information acquired during the proposed work will be transferred to the fisheries community by presentations at meetings and workshops, by personal contact, by annual and final reports to the U.S. Army Corps of Engineers, and through scientific publications.

KEY PERSONNEL AND DUTIES

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Table 1. Proposed fixed-site telemetry receivers for evaluating passage behavior of radio-tagged juvenile salmonids at Lower Monumental Dam, 2007.

Site description	Type of monitoring	Antenna type
Forebay north shore	Entrance line and residence time	3-element Yagi
Forebay mid channel	Entrance line and residence time	3-element Yagi
Forebay south shore	Entrance line and residence time	3-element Yagi
Turbine unit 1	Approach and passage	Striped coax
Turbine unit 2	Approach and passage	Striped coax
Turbine unit 3	Approach and passage	Striped coax
Turbine unit 4	Approach and passage	Striped coax
Turbine unit 5	Approach and passage	Striped coax
Turbine unit 6	Approach and passage	Striped coax
Draft tube for turbine 1	Project passage	Underwater dipole
Draft tube for turbine 2	Project passage	Underwater dipole
Draft tube for turbine 3	Project passage	Underwater dipole
Draft tube for turbine 4	Project passage	Underwater dipole
Draft tube for turbine 5	Project passage	Underwater dipole
Draft tube for turbine 6	Project passage	Underwater dipole
Spillbay 8 (RSW)	Approach and passage	Underwater dipole
Spillbay 7	Approach and passage	Underwater dipole
Spillbay 6	Approach and passage	Underwater dipole
Spillbay 5	Approach and passage	Underwater dipole
Spillbay 4	Approach and passage	Underwater dipole
Spillbay 3	Approach and passage	Underwater dipole
Spillbay 2	Approach and passage	Underwater dipole
Spillbay 1	Approach and passage	Underwater dipole
Stilling basin south shore	Project passage	Tuned loop
Stilling basin north shore	Project passage	Tuned loop
Juvenile bypass system	Bypass passage	Tuned loop
Tailrace exit north shore	Project passage and tailrace egress	3-element Yagi
Tailrace exit south shore	Project passage and tailrace egress	3-element Yagi

Table 2. Proposed fixed-site telemetry receivers for evaluating passage behavior of juvenile salmonids at Ice Harbor Dam, 2007.

Site description	Type of monitoring	Antenna type
Forebay north shore	Entrance line and residence time	3-element Yagi
Forebay mid channel	Entrance line and residence time	3-element Yagi
Forebay south shore	Entrance line and residence time	3-element Yagi
Turbine unit 1	Approach and passage	Striped coax
Turbine unit 2	Approach and passage	Striped coax
Turbine unit 3	Approach and passage	Striped coax
Turbine unit 4	Approach and passage	Striped coax
Turbine unit 5	Approach and passage	Striped coax
Turbine unit 6	Approach and passage	Striped coax
Draft tube for turbine 1	Project passage	Underwater dipole
Draft tube for turbine 2	Project passage	Underwater dipole
Draft tube for turbine 3	Project passage	Underwater dipole
Draft tube for turbine 4	Project passage	Underwater dipole
Draft tube for turbine 5	Project passage	Underwater dipole
Draft tube for turbine 6	Project passage	Underwater dipole
Spillbay 1	Approach and passage	Underwater dipole
Spillbay 2 (RSW)	Approach and passage	Underwater dipole
Spillbay 3	Approach and passage	Underwater dipole
Spillbay 4	Approach and passage	Underwater dipole
Spillbay 5	Approach and passage	Underwater dipole
Spillbay 6	Approach and passage	Underwater dipole
Spillbay 7	Approach and passage	Underwater dipole
Spillbay 8	Approach and passage	Underwater dipole
Spillbay 9	Approach and passage	Underwater dipole
Spillbay 10	Approach and passage	Underwater dipole
Stilling basin south shore	Project passage	2-element Yagi
Stilling basin north shore	Project passage	2-element Yagi
Juvenile bypass system	Bypass passage	Tuned loop
Tailrace exit north shore	Project passage and tailrace egress	3-element Yagi
Tailrace exit south shore	Project passage and tailrace egress	3-element Yagi

Table 3. Assumptions used for estimating precision for proposed sample sizes for estimating survival and fish passage behavior at Lower Monumental (LMN) and Ice Harbor Dam (IHR) yearling and subyearling Chinook salmon and juvenile steelhead in 2007.

	Yearling Chinook salmon		Juvenile steelhead		Subyearling Chinook salmon	
Assumptions	LMN	IHR	LMN	IHR	LMN	IHR
Treatment survival to entry	0.95	0.84	0.95	0.84	0.95	0.95
Entry detection probability	0.95	0.95	0.95	0.95	0.95	0.95
Forebay survival	0.95	0.95	0.95	0.95	0.95	0.95
Spillway passage proportion	0.75	0.75	0.75	0.75	0.80	0.75
RSW passage proportion	0.45	0.45	0.45	0.45	0.60	0.60
Survival tailrace to primary array	0.95	0.95	0.95	0.95	0.95	0.95
Detection probability primary array	0.95	0.95	0.95	0.95	0.95	0.95
Lambda	0.90	0.85	0.90	0.85	0.85	0.85

Table 4. Proposed sample sizes for tagging and release by objective for yearling and subyearling Chinook salmon and juvenile steelhead for evaluating fish passage behavior and survival studies at Lower Monumental and Ice Harbor Dams in 2007.

Release Group	Objective	Yearling Chinook	Juvenile steelhead	Subyearling Chinook
LMN Treatment	1, 2, and 3	1,528	1,528	1,269
LMN Reference	1, 2, and 3	1,440	1,440	1,185
IHR Treatment	4,5, and 6	(2,374[1])	(2,374[1])	1.269
IHR Reference	4,5, and 6	1,396	1,398	1,182
Total		4,364	4,366	4,905

[1]Treatment groups will be created by regrouping fish released as part of Objective 1 and 2 that subsequently enter into the Ice Harbor Dam study area at the upstream end of the BRZ which is expected to be at least 80%.

Table 5. Estimated precision (95% CI) ($\alpha = 0.05$, $\beta = 0.50$) of survival estimates by project operation and dam (LMN = Lower Monumental Dam, IHR = Ice Harbor Dam) for proposed sample sizes of yearling and subyearling Chinook salmon and juvenile steelhead for evaluating fish passage behavior and survival studies at Lower Monumental and Ice Harbor Dams in 2007.

	Dam survival		Spillway survival		RSW survival	
Species	LMN	IHR	LMN	IHR	LMN	IHR
Yearling Chinook salmon	0.033	0.028	0.032	0.028	0.039	0.033
Juvenile steelhead	0.033	0.028	0.032	0.028	0.039	0.033
Subyearling Chinook salmon	0.038	0.039	0.037	0.039	0.041	0.042

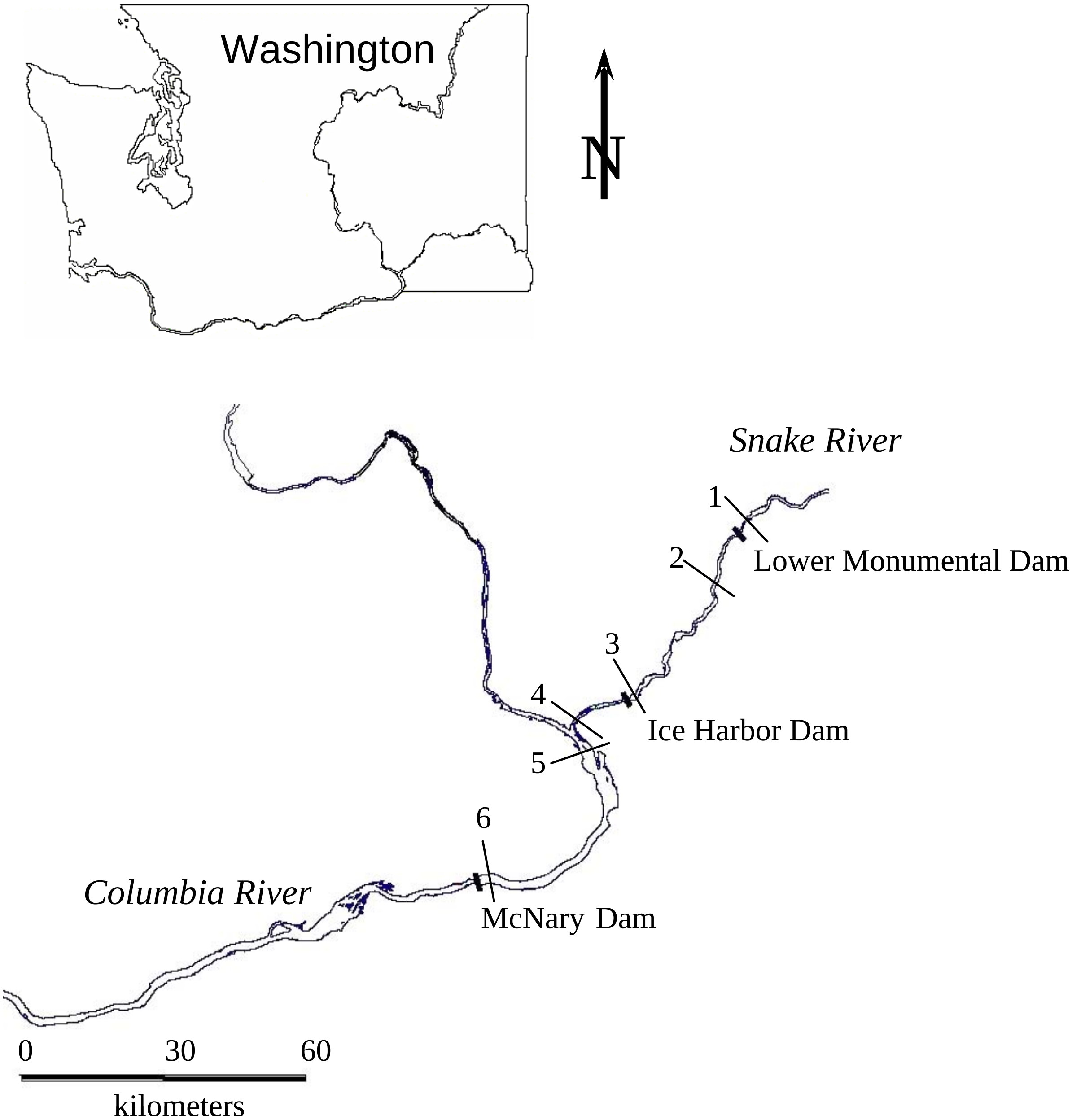

Figure 1. Detail of the study area showing locations of radiotelemetry transects used for estimating survival at Lower Monumental and Ice Harbor Dams in 2007. Transects include: 1 = forebay of Lower Monumental Dam, 2 = Burr Canyon, 3 = forebay of Ice Harbor Dam, 4 = mouth of the Snake River; 5 = Burbank/Finely Railroad Bridge and 6 = forebay of McNary Dam. The tailrace, and all routes of passage at Lower Monumental and Ice Harbor Dams will also monitored.

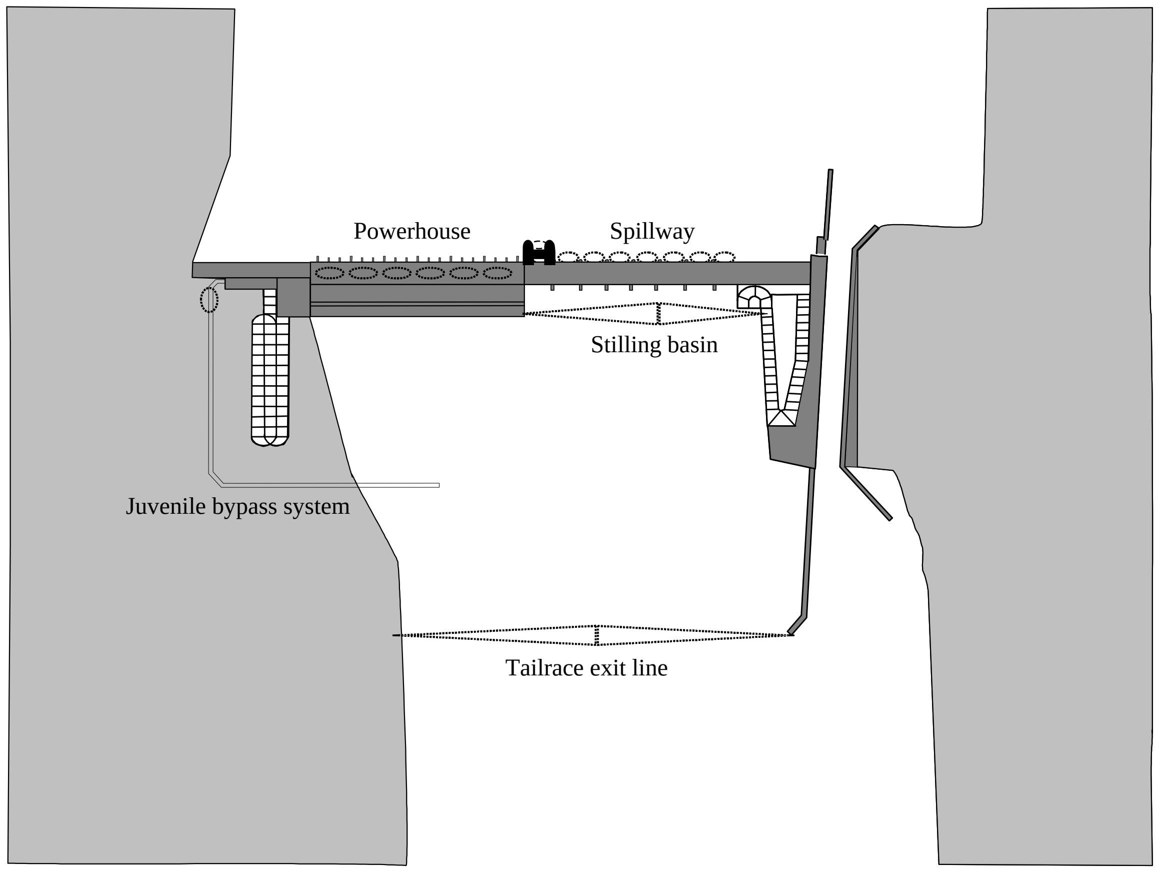

Figure 2. Plan view of Lower Monumental Dam showing proposed radiotelemetry detection zones for 2007 (Note: Dashed ovals represent underwater antennas. Dashed triangles represent aerial antennas).

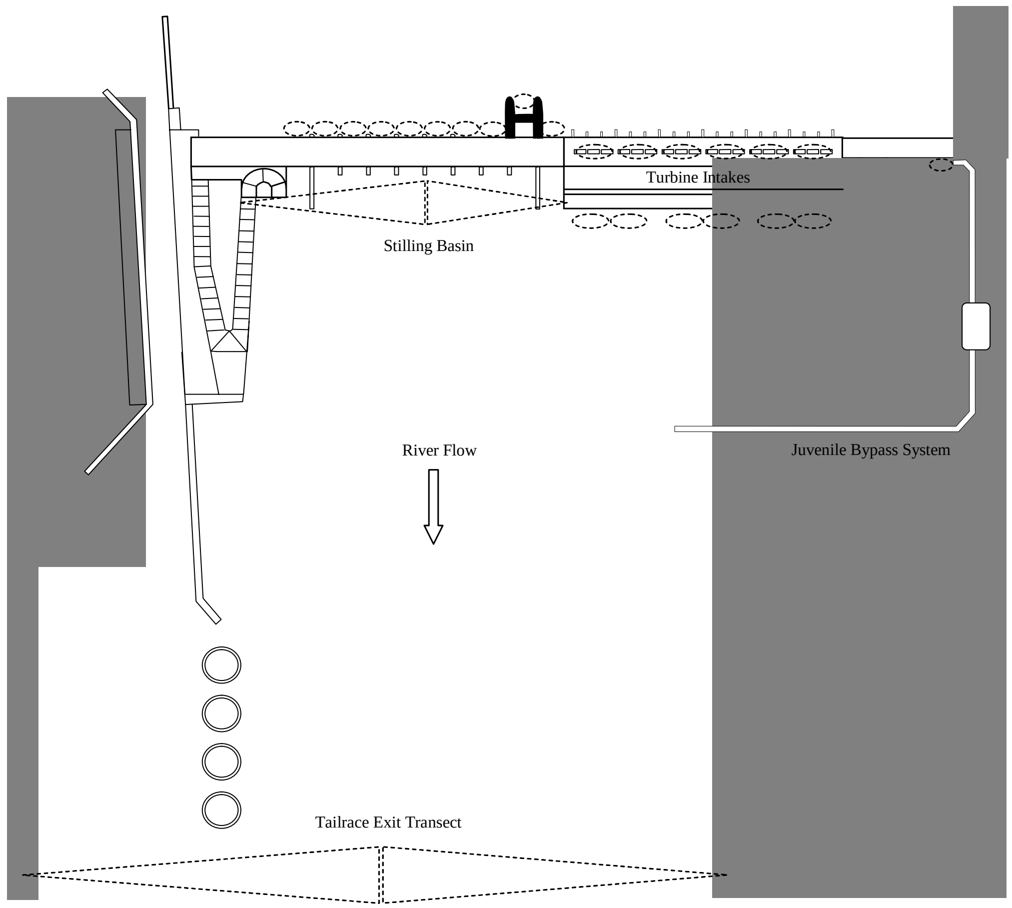

Figure 3. Plan view of Ice Harbor Dam showing approximate radiotelemetry detection zones for proposed evaluation of passage behavior and survival at Ice Harbor Dam in 2007 (Note: Dashed ovals represent underwater antennas. Dashed triangles represent aerial antennas).

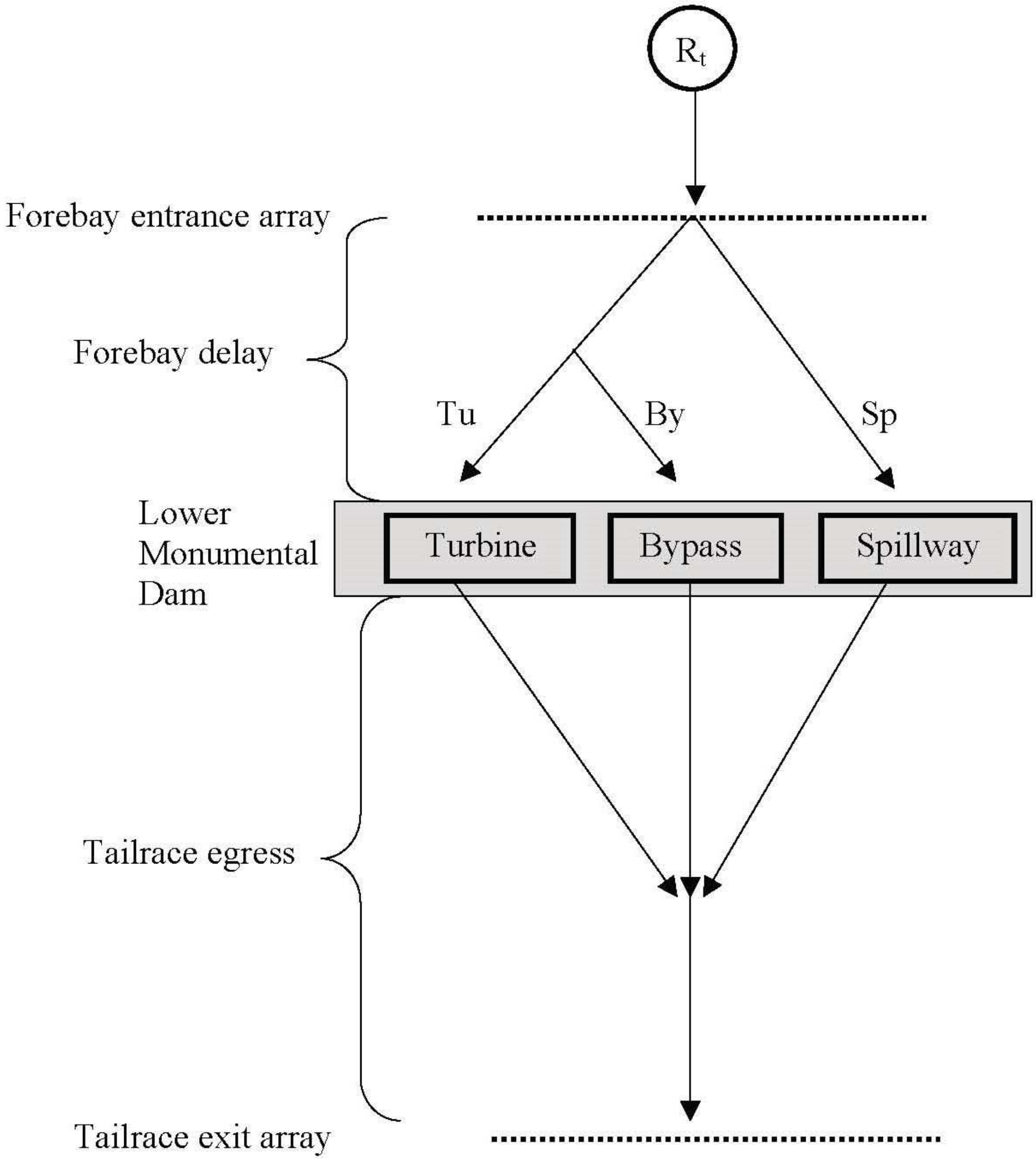

Figure 4. Schematic of passage behavior study design showing release sites, passage routes, and parameters used to estimate passage metrics at Lower Monumental Dam. Shown are the treatment releases (R_t) upstream of Lower Monumental Dam and estimable parameters. Estimable parameters include forebay delay, passage routes (Tu = Turbines, By = Juvenile Bypass, and Sp = Spillway), and tailrace egress.

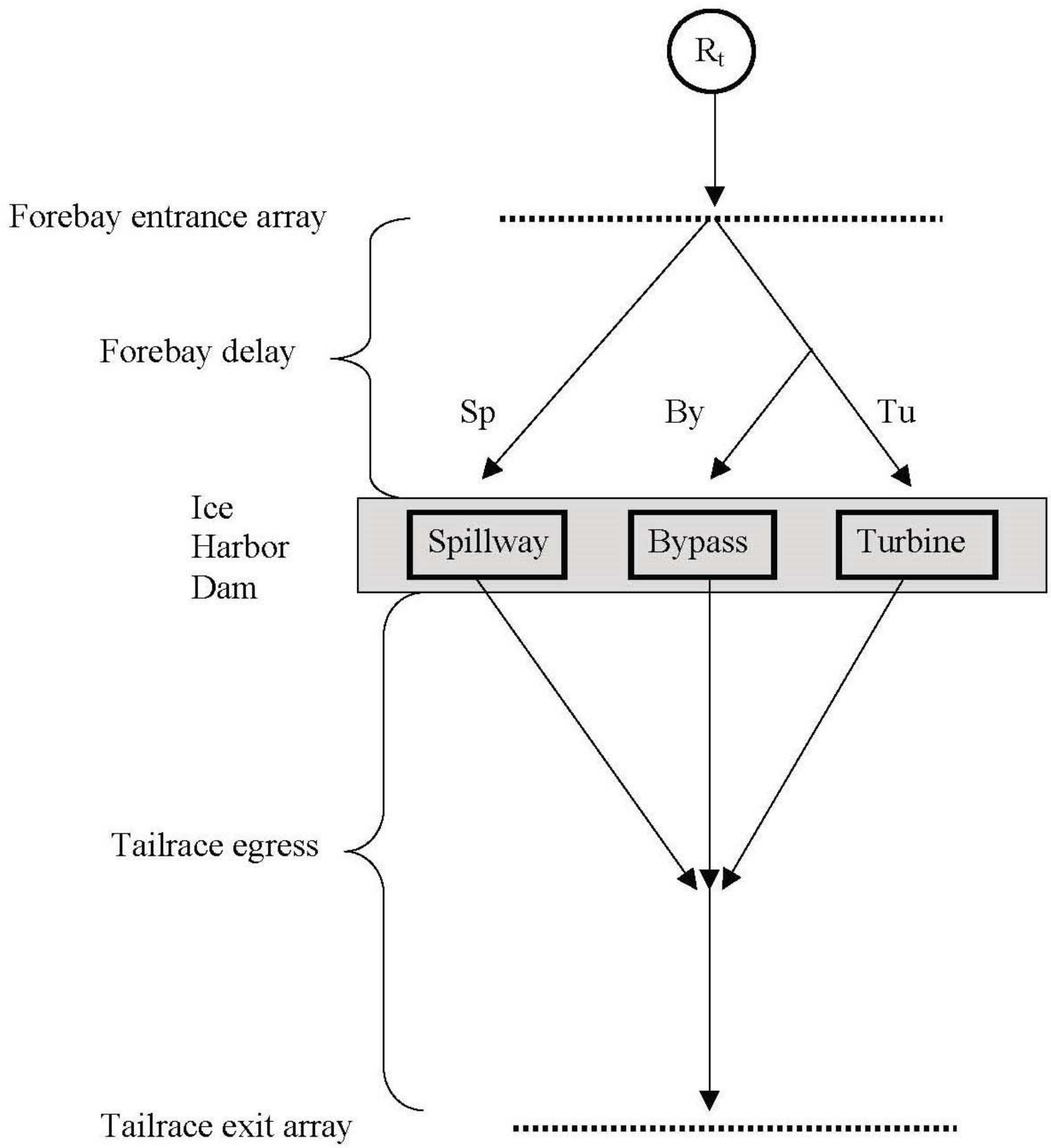

Figure 5. Schematic of passage behavior study design showing release sites, passage routes, and parameters used to estimate passage metrics at Ice Harbor Dam. Shown are the treatment releases (R_t) upstream of Ice Harbor Dam and estimable parameters. Estimable parameters include forebay delay, passage routes (Tu = Turbines, By = Juvenile Bypass, and Sp = Spillway), and tailrace egress.

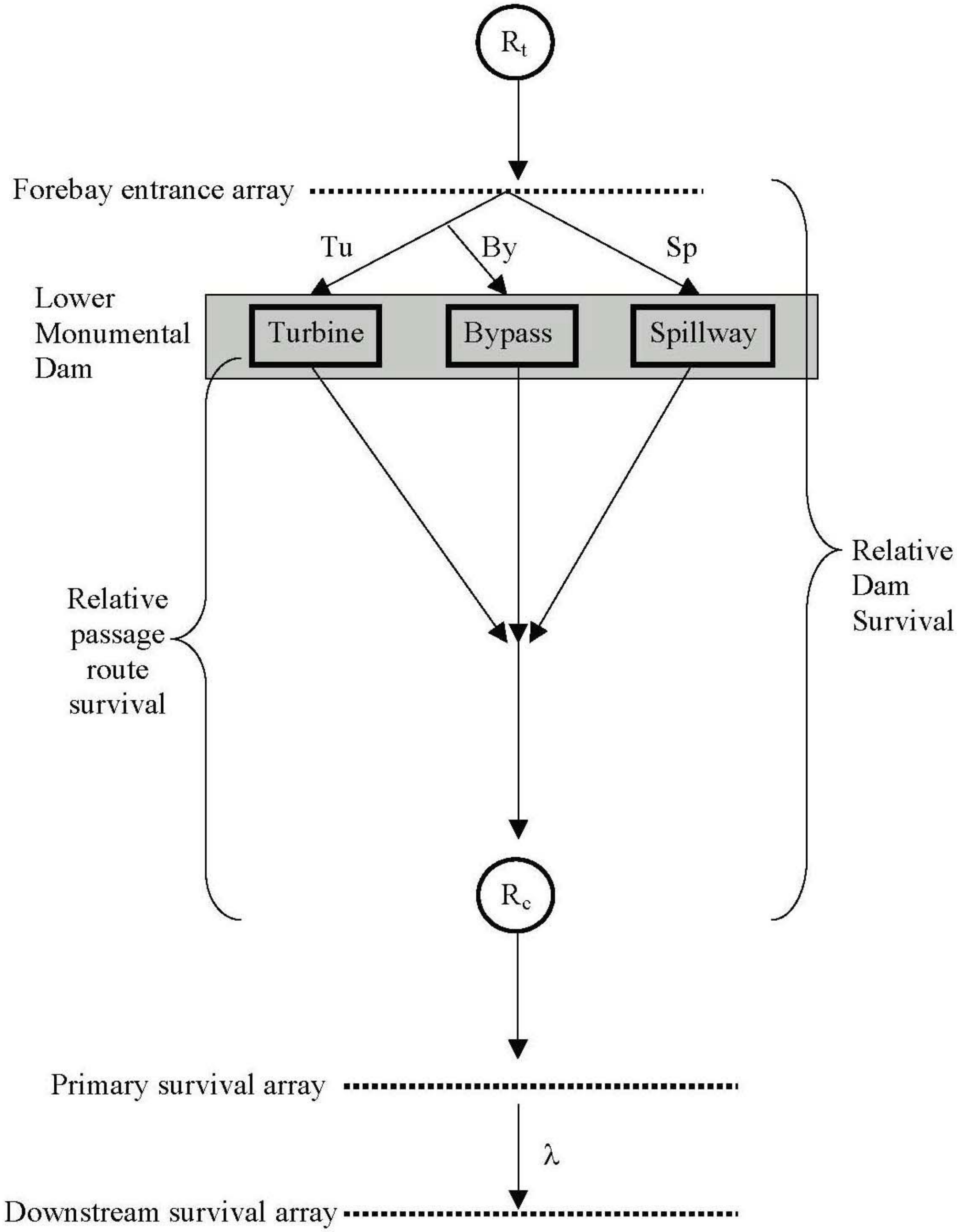

Figure 6. Schematic of relative survival model showing release sites, passage routes, and parameters used to estimate relative survival at Lower Monumental Dam. Shown are the treatment releases (R_t) upstream of Lower Monumental Dam, control releases in the tailrace (R_c), and estimable parameters. Estimable parameters include relative dam survival and relative passage route survival. Lambda (λ) is the joint probability of surviving to and detection at downstream arrays.

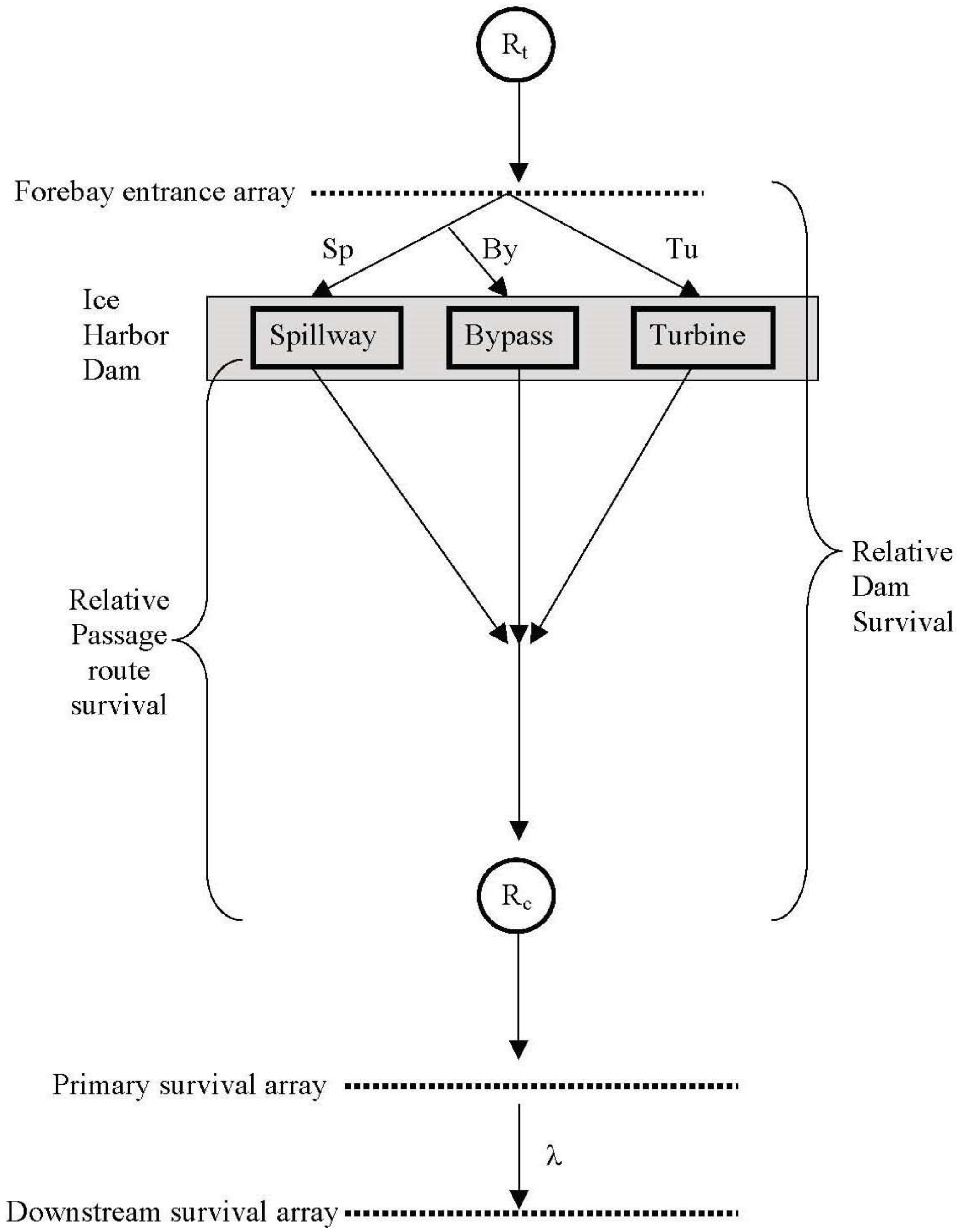

Figure 7. Schematic of relative survival model showing release sites, passage routes, and parameters used to estimate relative survival at Ice Harbor Dam. Shown are the treatment releases (R_t) upstream of Ice Harbor Dam, control releases in the tailrace (R_c), and estimable parameters. Estimable parameters include relative dam survival and relative passage route survival. Lambda (λ) is the joint probability of surviving to and detection at downstream arrays.